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Subject: Review of Monument Fire

To: Whitman Unit Ranger, Wallowa-Whitman National Forest
District Ranger, Prairie City Ranger District, Malheur National Forest

On October 10, 2002 we visited the Unity Ranger District at the request of Jim Gilsdorf, Operations Team Leader. The purpose of our visit was to review tree injury on the Monument Fire that occurred during July of 2002. We were asked to address the issue of potential tree mortality in partially burned areas of the Monument Fire. In particular, the district was concerned about the survivability of a number of large diameter ponderosa pines that appeared to be alive at the time of our review, but had experienced varying amounts of damage to mostly the bole, and possibly root systems.

Jim accompanied us to the field and gave us an overview of representative damage that occurred across the burn by driving the road system through the fire. We stopped in a couple of places to examine damage to large trees where there were specific concerns about "green" tree survivability. The following paragraphs summarize our observations and discussions relevant to survival of conifers injured by the Monument Fire. Although we examined only a small portion of the total fire area on the Unity RD, our discussion is applicable to similar stands, with similarly damaged trees, in other portions of the Monument Fire, including the larger portion of the fire that burned on the Prairie City RD, Malheur NF.

Background

The Monument Fire, located approximately 9 miles southwest of Unity, Oregon and 23 miles southeast of Prairie City, Oregon, resulted from ignition of natural forest fuels by lightning strikes during a series of large thunderstorms that passed through the Blue Mountains of northeastern Oregon on July 12, 2002. The 24,525-acre fire, which started in the Little Malheur River Basin on the Prairie City RD, Malheur NF in Grant County, spread to the Unity RD, Wallowa-Whitman NF in Baker County over the next several days. While most of the damage (82%, or 20,186 acres) occurred on the Prairie City RD, about 3,711 acres (15% of the total area) burned on the Unity RD, and an additional 628 acres (3%) burned on private land.

The warm-dry biophysical environment of the Monument Fire area historically experienced a fire regime that had short fire-return intervals, allowing for frequent, low-intensity surface fire to creep across the forested landscape in a mosaic burn pattern and maintain the species dominance in fire-resistant ponderosa pine on dry sites, and western larch on moister sites. Shade-tolerant grand fir and Douglas-fir that seeded in during the intervals between periodic fires had greater susceptibility to fire during early stages of growth due to thin bark and shallow root systems, and were frequently removed by the frequent low-intensity fire events. However, with the implementation of active fire suppression policy, and the advent of livestock grazing and selective timber harvest of fire-tolerant conifer species beginning in the early 1900s, the



landscape began to change from open park-like ponderosa pine dominated stands with grassy undergrowth to dense multistoried mixed conifer stands containing an understory of fire-intolerant tree species (Gast et al. 1991; Johnson 1994; Mutch et al. 1993). The vegetation changes brought about changes in fire regimes, as well. The frequent, low-intensity surface fire regime gave way to the less frequent mixed-severity or high-severity stand-replacement fire regimes that occur more commonly today in the warm-dry formerly pine dominated plant communities.

Large wildfires of the magnitude of the Monument Fire are occurring with greater frequency and at higher severity in mixed conifer stands because of the higher total and dead fuel loads and greater horizontal and vertical fuel continuity (Agee 1993). During historic fire regimes in these pine-dominated communities, pines were maintained and were able to advance to mature age because they were the more fire-adapted species and could survive frequent surface fires. Fewer remnant, large-diameter ponderosa pines exist in these stands today, and they are not regenerating due to the lack of periodic disturbances from frequent, low-intensity surface fire of the former fire regime. There is greater likelihood for loss of these mature stand components from wildfires that occur under vegetation conditions of today.

Observations and Discussion

The Monument Fire, in most areas, was fueled by the combustion of an accumulation of natural fuel components and densely stocked true fir and Douglas-fir ladder fuels comprising the understory of affected stands. The fire burned with moderate to high intensity over most of the areas we were able to view from the road system, and by walking through portions of the fire. In areas where we stopped to examine the status of trees with green crowns, we observed that nearly all the understory vegetation had been consumed by the fire, and in most places the fire had burned through the litter layer and most, if not all, of the duff layer, exposing the mineral soil.

The nature of injuries to conifers undergoing burn conditions varies depending on the structure and arrangement of fuels and proximity to the tree, the intensity and duration of heat generated during combustion of fuels, the relative resistance to fire of the conifer species occupying the area burned and relative size of the tree, and various other factors. Agee (1993) describes several ways trees are injured by fire. Heated gases that are generated within a zone above the flaming portion of the fire reach temperatures that kill living tissue and may kill a portion or all of the foliage of the crown, as well as the buds that have developed on branch tips. The maximum height of this zone is related to fireline intensity, the ambient temperature, and the windspeed (Van Wagner 1973, cited in Agee 1993). In addition to crown damage, the bole of trees may be heated to a temperature where part or all of the cambium that is normally protected beneath the bark is killed, or root systems may be heated and killed.

In many instances on the Monument Fire, small diameter trees of all species were lethally injured, if not consumed outright by the fire. Other cases occurred where small- and medium-size trees of different species were only partially injured because of exposure to less intense heat and different surface fire behavior. Some of these will survive, but for many others, their survival over the long term is questionable. Woodboring beetle (families Cerambycidae and Buprestidae) populations commonly build up large numbers in fire-injured trees over the first several years after the fire and often attack and kill trees that initially survived the fire. This has

been especially common in pole-size ponderosa pines on several wildfires we have monitored in recent years. We would anticipate that to be the case in these situations on the Monument Fire, as well.

Fire frequently kills tree species less adapted to fire such as many of the true firs that were growing in stands burned by the Monument Fire. Grand firs, and sometimes the small sawlog-size and smaller Douglas-firs, succumb to varying fire injuries characterized by scorch to the bole and crown. The buds of these conifers are particularly sensitive to fire and crown scorch is often lethal to buds as well as needles. By contrast, the large resinous buds of ponderosa pines are partially protected from heat by the long needles surrounding them, and they may often survive in the same heat conditions that kill true fir and Douglas-fir buds when exposed to fire.

Grand fir of various size classes can be killed by fire girdling the thin bark around the root crown area that occurs during long-duration smoldering or glowing combustion of duff at the base of the tree, even though the crown appears green for some time after the fire (Scott et al. 1996). In these cases, the phloem and cambium at the base of the tree has been irreparably damaged by fire, but the tree still has functioning xylem taking up water to the crown, enabling the crown to remain green for a year or more after the fire. These trees die when they have used up their stored carbohydrate reserves, and are unable to repair root injuries and replace fine roots due to disruption of carbohydrate flow through the injured phloem at the base. As trees age, and bark becomes thicker, true firs become more fire tolerant and may survive a ground fire since the degree of protection of cambium by bark during a fire increases with the square of the bark thickness (Agee 1993). This may explain the occasional presence of large-diameter overmature fire-scarred grand firs in some older ponderosa pine-dominated stands.

Large diameter Douglas-firs injured by fire are frequently attractive to Douglas-fir beetles, *Dendroctonus pseudotsugae*. We have observed in some wildfires where these beetles have built up large populations in large diameter fire-injured trees and then spread to other green Douglas-firs in stands adjacent to the fire. We are not aware to what extent this situation may exist on the Monument Fire, but where larger Douglas-firs occur within the fire perimeter, particularly those 20-inches dbh and larger, they bear watching.

Undoubtedly of greatest interest to the Unity District are observations and discussions of the conditions of the remnant mature and overmature ponderosa pines in various areas of the Monument Fire. One of the first areas we visited on the burn was a stand containing several larger diameter ponderosa pines that had not sustained major visible injuries from the fire. We observed some bole charring that apparently had not been lethal to the cambium; and likewise, crown scorching was either absent on trees, or not serious enough to put the trees at risk of mortality. Both injuries, alone or in combination, can kill the tree if serious enough, or put the weakened tree at risk of attack by bark beetle species such as by the western pine beetle, *Dendroctonus brevicomis*. For example, the effect of crown defoliation by fire on subsequent bark beetle-caused mortality of ponderosa pine has been modeled by a second-order polynomial equation given in figure 1 (Scott 2002). This equation, developed from data described by Miller and Keen (1960), demonstrates how scorched or killed foliage on ponderosa pine can predispose trees to attack by western pine beetle, depending on the proportion of the crown volume killed by fire.

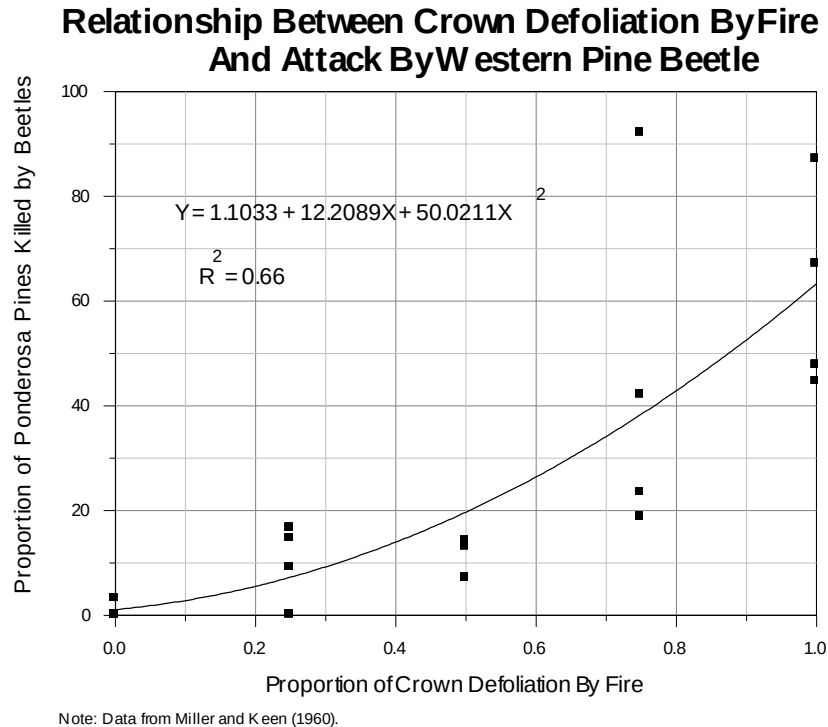


Figure 1. Relationship of ponderosa pine crown defoliation by fire and lethal attack by western pine beetle.

A few years ago on the Summit Fire (Malheur National Forest), one of the few groves of large-diameter mature ponderosa pines that survived the initial fire was killed by western pine beetles. Moreover, in the following 2 or 3 years, beetle populations dramatically increased on the fire area and killed many of the smaller pines that had also initially survived the fire. The outbreak finally collapsed after the third year of the infestation due to a combination of factors. While these types of outbreaks do not occur regularly after wildfires, if conditions are favorable for insect breeding and populations maintain relatively high brood survival rates, they will occur.

Root damage to large pines after wildfire is often inconspicuous; consequently, crews surveying the post-fire damage to trees may be unaware of it or tend to ignore it. Root damage usually accompanies bole damage, so its effects also may be confounded with heating of the basal portion of the tree stem (Agee 1993); and this fact may make it more difficult to assess the impact associated with root damage alone. However, this damage may play a key role in the post-fire survival of these trees.

Although the effects of wildfire injury on roots of large pines have only been partially studied, there is beginning to accumulate a body of evidence that suggests that the combustion of deep accumulations of litter and duff over the roots of these large pines is much more damaging than first thought. When the periodic removal of litter and duff from beneath these large pines once or twice a decade from historic surface fire regimes ceases, the fine roots tend to extend into the deep duff and litter layer that gradually accumulates around the bole. Damage to fine roots of large pines from even low-intensity underburns occurs when deep duff that accumulated after many decades of fire protection is slowly consumed during the glowing or smoldering combustion of the litter and duff. Fine roots may be consumed during duff consumption, or

merely damaged. Fine roots are more easily damaged by fire than larger roots because of thinner bark (Agee 1993). Fine root damage by fire has been associated with both growth reductions in young ponderosa pine stands (Grier 1989), and with tree mortality in low vigor, old-growth ponderosa pine stands (Swezy and Agee 1991). Sackett (1987) presented evidence that cambial and root damage may be significant for old ponderosa pines when underburns slowly consume the large accumulation of old needles and bark flakes at the base of the tree. Intense heat is created by combustion of deep accumulations of these materials, and during slow glowing combustion the long duration of heating applied over the root systems drives the heat downward into the sensitive root tissues, killing them.

We observed that in several of the mature pines at the first site we visited, the litter and duff layers had been entirely consumed to mineral soil, or nearly so. Often, in these cases, this amounted to consumption of a considerable depth of accumulated sloughed-off bark scales and needles in various stages of decomposition. In other situations, both prescribed fire and wildfire, we have observed that trees with this amount of duff reduction will survive a few years, and then be attacked and killed by woodborers or bark beetles, sometimes as long as 3 or 4 years after the fire. Apparently, there has been enough injury to the root system in these instances that the tree never fully recovers, but instead suffers from stress in a similar manner to trees experiencing drought stress, and thereby becomes attractive to bark beetles and woodborers. Large pines that did not have the duff completely consumed may stand a better chance of long-term survival because of potentially less damage to fine roots that may be in the unburned portion of the duff. But, in all these cases, only long-term monitoring will bear this out.

In the case of the large pines we observed in the Monument Fire, our best guess based on past experience and a reading of the literature, incomplete as it is, is that many of these trees having complete duff consumption, or near-complete duff consumption will likely not survive much more than 5 years from the time of injury from the fire. However, younger pines, even though duff may have been completely consumed seem to fare better because the residence time of the fire over the root system is typically much shorter owing to the much shallower depth of accumulated duff layer. We anticipate this to be the case on the Monument Fire, having observed this on long-term monitoring plots in several other wildfires. Moreover, we believe these generalizations concerning ponderosa pines hold true for other areas with similar stand conditions and tree injuries on the Monument Fire that we were not able to see during this review. Nevertheless, we suggest the districts monitor this situation where large-diameter fire-injured pines are anticipated to be retained in stands. We are available to help develop a long-term (at least 5 year) plan to monitor the large pines in a standardized manner consistent with other monitoring that is on-going.

In addition, to help districts determine the relative survivability of various species of conifer trees injured by fire, we have recently developed a rating system (see Scott et al. 2002) to assess damage to roots, bole, and crown of the trees along with several other factors. Within that document we suggested ranges of composite rating scores that allow the user to place the evaluated tree into 1 of 3 survivability categories: High, Moderate, and Low. We are enclosing a copy of that report along with this letter for your use.

Please contact any of us if you have questions regarding this report or if you need additional information.

DONALD W. SCOTT
Entomologist

LIA H. SPIEGEL
Entomologist

CRAIG L. SCHMITT
Pathologist

enclosure

cc: Jim Gilsdorf, Baker RD
Bob Rock, WAW
Victoria Rockwell, WAW
Ken Rockwell, WAW
Ken Kincaid, Prairie City RD, MAL
Bill McArthur, MAL
Chris Niwa, PNW-Corvallis, OR
Andy Youngblood, PNW-La Grande, OR
Dave Overhulser, Oregon Department of Forestry, Salem, OR
Dick Watson, BLM, Baker Resource Area
Don Scott
Lia Spiegel
Craig Schmitt

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